

What is claimed is:

1. A digital television (DTV) transmitter, comprising:

5 an input means for receiving a digital video data stream including normal data and robust data;

an encoding means for coding the digital video data stream into data symbols; and

10 a transmitting means for modulating and transmitting an output signal of the encoding means,

wherein the encoding means performs 16-state trellis coding on the robust data.

2. The DTV transmitter as recited in claim 1, wherein the encoding means maps the normal data into any one data symbol of $\{-7, -5, -3, -1, 1, 3, 5, 7\}$.

3. The DTV transmitter as recited in claim 1, wherein the encoding means includes:

20 a robust encoder for coding the robust data into 2-bit data symbols; and

a trellis encoder for outputting a data symbol of any one level among predetermined levels expressed in three bits based on the 2-bit data symbols.

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4. The DTV transmitter as recited in claim 3, wherein the robust encoder encodes the 2-bit data symbols in such a manner that an output symbol level of the trellis encoder and a subsequent state are respectively the same as shown in tables:

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| CURRENT STATE | INPUT | | | | | | | | | | | | | | | |
|---------------|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -7 | -5 | -7 | -5 | 1 | 3 | 1 | 3 | -3 | -1 | -3 | -1 | 5 | 7 | 5 | 7 |
| 1 | 1 | 3 | 1 | 3 | -7 | -5 | -7 | -5 | 5 | 7 | 5 | 7 | -3 | -1 | -3 | -1 |

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| | | | | | | | | | | | | | | | | | |
|---------------|---|-------|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 5 | 7 | 4 | 6 | 5 | 7 | 4 | 6 |
| | 1 | 12 | 14 | 13 | 15 | 12 | 14 | 13 | 15 | 9 | 11 | 8 | 10 | 9 | 11 | 8 | 10 |

5. The DTV transmitter as recited in claim 3, wherein the robust encoder encodes the 2-bit data symbols in such a manner that an output symbol level of the trellis encoder and a subsequent state are respectively the same as shown in tables:

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| | | | | | | | | | | | | | | | | | |
|---------------|---|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 |
| | 1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 |

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| | | | | | | | | | | | | | | | | | |
|---------------|---|-------|----|----|----|---|----|---|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 |
| | 1 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 |

6. The DTV transmitter as recited in any one of claims 3 to 5, wherein the encoding means further includes:

a data randomizer for randomizing an output signal of the input means;

a Reed Solomon (RS) encoder for performing RS encoding on an output signal of the data randomizer;

30 a robust interleaver/packet formatter for interleaving only robust data among output signals of the RS encoder and reconstructing the interleaved robust data into robust data packets based on a robust data coding rate; and

35 a data interleaver for interleaving an output signal of the robust interleaver/packet formatter.

7. A digital television (DTV) receiver, comprising:
 a receiving means for receiving a transmission signal
 including normal data and robust data and converting the
 received transmission signal into a baseband signal;

5 an equalizing means for determining a symbol level of
 the transmission signal;

a trellis decoding means for performing trellis
 decoding on the symbol whose level has been determined; and

10 a decoding means for outputting a digital video data
 stream with respect to the trellis decoded signal,

wherein the trellis decoding means performs 16-state
 trellis decoding on the robust data.

8. The DTV receiver as recited in claim 7, wherein
 15 the trellis decoding means decodes the determined symbol
 level into a 2-bit data symbol in such a manner that a
 symbol level and a subsequent state of the robust data are
 respectively the same as shown in tables:

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| | | | | | | | | | | | | | | | | | |
|------------------|---|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | -7 | -5 | -7 | -5 | 1 | 3 | 1 | 3 | -3 | -1 | -3 | -1 | 5 | 7 | 5 | 7 |
| | 1 | 1 | 3 | 1 | 3 | -7 | -5 | -7 | -5 | 5 | 7 | 5 | 7 | -3 | -1 | -3 | -1 |

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CURRENT STATE

INPUT

| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|
| 0 | 0 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 5 | 7 | 4 | 6 | 5 | 7 | 4 | 6 |
| 1 | 1 | 12 | 14 | 13 | 15 | 12 | 14 | 13 | 15 | 9 | 11 | 8 | 10 | 9 | 11 | 8 | 10 |

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9. The DTV receiver as recited in claim 7, wherein
 the trellis decoding means decodes the determined symbol
 level into a 2-bit data symbol in such a manner that a
 35 symbol level and a subsequent state are respectively the

same as shown in tables:

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CURRENT STATE

INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 |
| 1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 |

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CURRENT STATE

INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|---|----|---|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 |
| 1 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 |

10. The DTV receiver as recited in any one of claims 7 to 9, wherein the decoding means includes:

15 a data deinterleaver for deinterleaving a signal outputted from the trellis decoding means;

a packet formatter/robust deinterleaver for reconstructing robust data among signals outputted from the data deinterleaver into robust data packets formed of information data and deinterleaving the reconstructed robust data packets;

a Reed Solomon (RS) decoder for performing RS decoding on output signals of the packet formatter/robust deinterleaver;

25 a data derandomizer for derandomizing output signals of the RS decoder; and

a demultiplexer for demultiplexing output signals of the data derandomizer.

30 11. A digital television (DTV) transmitting method, comprising the steps of:

a) inputting a digital video data stream including normal data and robust data;

35 b) coding the digital video data stream into data symbols; and

c) modulating and transmitting an output signal of the encoding step b),

wherein 16-state trellis coding is performed on the robust data in the encoding step b).

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12. The DTV transmitting method as recited in claim 11, wherein the normal data are mapped to any one data symbol of $\{-7, -5, -3, -1, 1, 3, 5, 7\}$ in the encoding step b).

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13. The DTV transmitting method as recited in claim 11, wherein the encoding step b) includes:

b1) coding the robust data into 2-bit data symbols; and

b2) outputting a data symbol of any one level among predetermined levels expressed in three bits based on the 2-bit data symbols.

14. The DTV transmitting method as recited in claim 13, wherein, in the robust encoding step b1), the 2-bit data symbols are encoded in such a manner that an output symbol level of the trellis encoding step b2) and a subsequent state are respectively the same as shown in tables:

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| | | | | | | | | | | | | | | | | | |
|---------------|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | INPUT | | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | -7 | -5 | -7 | -5 | 1 | 3 | 1 | 3 | -3 | -1 | -3 | -1 | 5 | 7 | 5 | 7 |
| | 1 | 1 | 3 | 1 | 3 | -7 | -5 | -7 | -5 | 5 | 7 | 5 | 7 | -3 | -1 | -3 | -1 |

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| | | | | | | | | | | | | | | | | | |
|---------------|-------|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|
| | INPUT | | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 5 | 7 | 4 | 6 | 5 | 7 | 4 | 6 |
| | 1 | 12 | 14 | 13 | 15 | 12 | 14 | 13 | 15 | 9 | 11 | 8 | 10 | 9 | 11 | 8 | 10 |

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15. The DTV transmitting method as recited in claim 13, wherein, in the robust encoding step b1), the 2-bit data symbols are encoded in such a manner that an output symbol level of the trellis encoding step b2) and a subsequent state are respectively the same as shown in tables:

| | | | | | | | | | | | | | | | | | |
|----|---------------|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| 10 | CURRENT STATE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 |
| | 1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 |

| | | | | | | | | | | | | | | | | | |
|----|---------------|-------|----|----|----|---|----|---|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| 15 | CURRENT STATE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 |
| | 1 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 |

16. The DTV transmitting method as recited in any one of claims 13 to 15, wherein the encoding step b) further includes:

b3) randomizing the input signal;

b4) performing RS encoding on an output signal randomized in the step b3);

b5) interleaving only robust data among output signals of the RS encoding step b4) and reconstructing the interleaved robust data into robust data packets based on a robust data coding rate; and

b6) interleaving an output signal of the robust interleaving/packet formatting step b5).

17. A digital television (DTV) receiving method, comprising the steps of:

a) receiving a transmission signal including normal data and robust data and converting the received transmission signal into a baseband signal;

b) determining a symbol level of the transmission signal;

c) performing trellis decoding on the symbol whose level has been determined; and

5 d) outputting a digital video data stream with respect to the trellis decoded signal,

wherein 16-state trellis decoding is performed on the robust data in the trellis decoding step c).

10 18. The DTV receiving method as recited in claim 17, wherein, in the trellis decoding step c), the determined symbol level is decoded into a 2-bit data symbol in such a manner that a symbol level and a subsequent state of the robust data are respectively the same as shown in tables:

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| CURRENT STATE | INPUT | | | | | | | | | | | | | | | |
|---------------|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -7 | -5 | -7 | -5 | 1 | 3 | 1 | 3 | -3 | -1 | -3 | -1 | 5 | 7 | 5 | 7 |
| 1 | 1 | 3 | 1 | 3 | -7 | -5 | -7 | -5 | 5 | 7 | 5 | 7 | -3 | -1 | -3 | -1 |

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| CURRENT STATE | INPUT | | | | | | | | | | | | | | | |
|---------------|-------|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 5 | 7 | 4 | 6 | 5 | 7 | 4 | 6 |
| 1 | 12 | 14 | 13 | 15 | 12 | 14 | 13 | 15 | 9 | 11 | 8 | 10 | 9 | 11 | 8 | 10 |

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19. The DTV receiving method as recited in claim 17, wherein, in the trellis decoding step c), the determined symbol level is decoded into a 2-bit data symbol in such a manner that a symbol level and a subsequent state are respectively the same as shown in tables:

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| | | | | | | | | | | | | | | | | | |
|---------------|---|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 |
| | 1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 |

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|---------------|---|-------|----|----|----|---|----|---|----|----|----|----|----|----|----|----|----|
| | | INPUT | | | | | | | | | | | | | | | |
| CURRENT STATE | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 0 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 |
| | 1 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 |

20. The DTV receiving method as recited in any one of claims 17 to 19, wherein the decoding step d) includes:

15 d1) deinterleaving a signal outputted from the trellis decoding step c);

d2) reconstructing robust data among signals outputted from the data deinterleaving step d1) into robust data packets formed of information data and deinterleaving the reconstructed robust data packets;

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d3) performing Reed Solomon (RS) decoding on output signals of the packet formatting/robust deinterleaving step d2);

d4) derandomizing output signals of the RS decoding step d3); and

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d5) demultiplexing output signals of the data derandomizing step d4).

21. A digital television (DTV) transmission signal, comprising:

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normal data mapped to any one data symbol of $\{-7, -5, -3, -1, 1, 3, 5, 7\}$;

robust data which are trellis coded in 16 states and mapped to any one data symbol of $\{-7, -5, -3, -1, 1, 3, 5, 7\}$; and

35 a robust data flag for identifying the normal data and

the robust data,

wherein the transmission signal is a Vestigial Side Band (VSB) modulated signal.

- 5 22. The DTV transmission signal as recited in claim 21, wherein the robust data are trellis coded in such a manner that an output symbol level and a subsequent state are respectively the same as shown in tables:

10 CURRENT STATE INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -7 | -5 | -7 | -5 | 1 | 3 | 1 | 3 | -3 | -1 | -3 | -1 | 5 | 7 | 5 | 7 |
| 1 | 1 | 3 | 1 | 3 | -7 | -5 | -7 | -5 | 5 | 7 | 5 | 7 | -3 | -1 | -3 | -1 |

15 CURRENT STATE INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 5 | 7 | 6 | 6 | 5 | 7 | 8 | 6 |
| 1 | 12 | 14 | 13 | 15 | 12 | 14 | 13 | 15 | 9 | 11 | 8 | 10 | 9 | 11 | 8 | 10 |

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23. The DTV transmission signal as recited in claim 21, wherein the robust data are trellis coded in such a manner that an output symbol level and a subsequent state are respectively the same as shown in tables:
- 25

30 CURRENT STATE INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 |
| 1 | 1 | 3 | 1 | 3 | 5 | 7 | 5 | 7 | -7 | -5 | -7 | -5 | -3 | -1 | -3 | -1 |

35 CURRENT STATE INPUT

| | | | | | | | | | | | | | | | | |
|---|----|----|----|----|---|----|---|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 | 0 | 2 | 1 | 3 | 9 | 11 | 8 | 10 |
| 1 | 12 | 14 | 13 | 15 | 9 | 7 | 8 | 6 | 12 | 14 | 13 | 15 | 5 | 7 | 4 | 6 |

24. The DTV transmission signal as recited in any
one of claims 21 to 24, wherein the normal data and
the robust data are interleaved to be mixed with each other,
and the robust data include a header to have backward
5 compatibility.